Title	New records and species of Canalisporium (Hyphomycetes), with a revision of the genus
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New records and species of *Canalisporium* (Hyphomycetes), with a revision of the genus

T.K. Goh, W.H. Ho, K.D. Hyde, S.R. Whitton, and T.E. Umali

Abstract: Three new species of *Canalisporium*, namely *Canalisporium exiguum* Goh & K.D. Hyde, *Canalisporium kenyense* Goh, W.H. Ho & K.D. Hyde, and *Canalisporium pallidum* Goh, W.H. Ho & K.D. Hyde, are described and illustrated. New records of *Canalisporium caribense*, *Canalisporium pulchrum*, and *Canalisporium elegans*, are given. They are also illustrated from fresh material and briefly discussed. Comparisons of conidial morphology of all species from different localities are made and a key to the species of the genus is provided.

Key words: *Berkleasmium*, dematiaceous hyphomycetes, freshwater fungi, lignicolous fungi, systematics.

Résumé : Les auteurs décrivent et illustrent trois nouvelles espèces de *Canalisporium*, nommément les *Canalisporium exiguum* Goh & K.D. Hyde, *Canalisporium kenyense* Goh, W.H. Ho & K.D. Hyde, et *Canalisporium pallidum* Goh, W.H. Ho & K.D. Hyde. Ils présentent également de nouvelles mentions pour les *Canalisporium caribense*, *Canalisporium pulchrum*, et *Canalisporium elegans*. Ceux-ci sont également illustrés à partir de matériel frais et brièvement discutés. Les auteurs comparent la morphologie conidiale de toutes les éspèces provenant de localités diverses et présentent une clé pour les espèces de ce genre.

Mots clés : *Berkleasmium*, hyphomycètes dématiés, champignons d'eau douce, champignons lignicoles, systématique.

[Traduit par la rédaction]

Introduction

The genus *Canalisporium* Nawawi & Kuthubutheen (1989) was introduced to accommodate *Berkleasmium caribense* Hol.-Jech. & Mercado, *Berkleasmium pulchrum* Hol.-Jech. & Mercado (Holubová-Jechová and Mercado Sierra 1984), and a third new species, *Canalisporium elegans* Nawawi & Kuthubutheen (1989). Conidia of *Canalisporium* species are muriform; however, they differ from those of *Berkleasmium* species in being flattened dorsiventrally, comprising a single layer of regularly arranged cells, which are supported by a small, thin-walled, cuneiform, pale basal cell.

In *Canalisporium caribense* (Hol.-Jech. & Mercado) Nawawi & Kuthub., conidia possess a single column of vertical septa, and 3–6 equally spaced rows of transverse septa. In *Canalisporium pulchrum* (Hol.-Jech. & Mercado) Nawawi & Kuthub., conidia have 2 columns of vertical septa, and 4–6 rows of transverse septa, while in *C. elegans*, conidia possess 4–5 columns of vertical septa, and 5–7 rows of transverse septa (Nawawi and Kuthubutheen 1989). These conidia, the septa of which usually become progressively darker with maturity, resemble cockroach cocoons. The most striking feature of the conidia, as suggested by the generic etymology, is the presence of narrow canals connecting adjacent cell lumens. Each of these canals is surrounded by a marked ring of pigmentation, visible as a circular disc in lateral view or a barrel shape in dorsiventral view. Conidia in species of *Berkleasmium* (Moore 1959; Ellis 1971, 1976) are distinctly cylindrical with randomly arranged septa and lack connecting canals between the cell lumens. The teleomorphs of *Canalisporium* species are presently unknown.

Canalisporium species are common saprophytes on rotten wood, and have a pantropical distribution. The genus has been recorded in Cuba (Holubová-Jechová and Mercado Sierra 1984), India (Rao and de Hoog 1986), Kenya (Kirk 1985), Malaysia (Nawawi and Kuthubutheen 1989), Taiwan (Matsushima 1987), and Uganda (Matsushima 1987). During our investigations of microfungi on submerged wood and other decaying plant material in the tropics, we have obtained several collections of *C. caribense*, *C. pulchrum*, and *C. elegans*. In one north Queensland collection, the conidia were similar to *C. caribense*, but were distinctly smaller. We therefore describe this fungus here as *Canalisporium exiguum* sp.nov. The conidial sizes of *C. caribense*, *C. pulchrum*, and *C. elegans* collected from various localities are compared in Tables 1, 2, and 3 and each species is illustrated and briefly discussed.

The type material of *B. pulchrum* (sensu Holubová-Jechová and Mercado Sierra 1984; *PRM 831528*) has conidia that are evenly pigmented, with a single, paler basal cell. We have examined a collection of "*Berkleasmium pulchrum*" (sensu Kirk 1985; *IMI 285428a*) from Kenya. The conidia in this collection were typical of *Canalisporium*, but do not conform to the above species, as the conidial body is borne on a horizontal row of three, thin-walled, subhyaline, small basal cells. Each horizontal row of cells differs clearly in wall thickness and pigmentation from the next row and the apical rows are

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Table 1. Comparison of conidial morphology in *Canalisporium caribense* from various localities.

Locality	Herbarium No.	Habitat	Length (µm)	Width (µm)	Lateral thickness (µm)	No. of columns of vertical septa	No. of rows of transverse septa	No. of cells in apical row	No.of cells per conidium*
Brunei	*HKUM 2910*	submerged wood	26–43	16–26	—	1	3–6	(1)–2	8–14
	HKUM 4902	*Freycinetia* sp.	32–38	20–24	10–12.5	1	3–4	2	9–13
	HKUM 4903	*Freycinetia* sp.	35–51	22–27	—	1	5–6	2	11–17
	HKUM 4904	*Pandanus* sp.	28–38	20–24	—	1	3–4	2	9–13
Cuba	*PRM 831526*	rotten branch	25–45	15–29	9.5–16	1	3–6	2	9–15
Hong Kong	*HKUM 3342*	submerged wood	32–38	22–29	10–12	1	3–5	2	9–13
	HKUM 3401	*Bambusa* sp.	25–30	15–20	10–12	1	3–4	2	9–11
Kenya	*IMI 284792a*	*Arundinaria* sp	24–36	16–22	8–12	1	5–6	2	13–15
Malaysia	*IMI 326601*	submerged wood	28–41	21–28	10–14	1	3–6	2	9–15
	HKUM 2883	submerged wood	21–36	16–24	—	1	3–5	2	9–13
Philippines	*HKUM 4905*	*Pandanus* sp.	23–32	17–20	10–12.5	1	3–4	2	9–13
	HKUM 4906	*Freycinetia* sp.	23–34	19–22	10–12.5	1	2–4	2	7–13
Taiwan	*MFC 6T811*	dead palm rachis	22–30	15–18	—	1	4–5	2	11–13
Uganda	*MFC 5275*	rotten wood	24–42	16–22	10–12	1	5–6	2	13–15
Vanuatu	*HKUM 4901*	*Pandanus* sp.	24–32	15–19	9–12	1	3–4	2	9–11

*Includes basal cell.

Table 2. Comparison of conidial morphology in *Canalisporium pulchrum* from various localities.

Locality	Herbarium No.	Habitat	Length (µm)	Width (µm)	Lateral thickness (µm)	No. of columns of vertical septa	No. of rows of transverse septa	No. of cells in apical row	No. of cells per conidium*
Australia	*HKUM 3192*	submerged wood	30–42	20–22	12–13	2	4–5	1–3	14–17
Brunei	*HKUM 2911*	submerged wood	25–63	16–25	10–16	2	3–9	1–3	11–31
Cuba	*PRM 831566*	rotten wood	31–46	23–32	13–16	2	3–7	1–3	13–21
Hong Kong	*HKUM 4741*	submerged wood	35–44	20–23	14–17	2	5–6	1–3	17–22
India	*CBS-H 3852*	rotten wood	28–50	20–29	15–17	2	3–6	mostly 1	11–20
Malaysia	*IMI 326602*	submerged wood	36–52	22–27	12–15	2	4–7	1–3	14–25

*Includes basal cell.

Table 3. Comparison of conidial morphology in *Canalisporium elegans* from various localities.

Locality	Herbarium No.	Habitat	Length (µm)	Width (µm)	Lateral thickness (µm)	No. of columns of vertical septa	No. of rows of transverse septa	No. of cells in apical row	No. of cells per conidium*
Brunei	*HKUM 4907*	*Freycinetia* sp.	37–48	25–38		3–4	5–7	1–5	27–41
	HKUM 2926	submerged wood	38–58	25–35	10–13	4–5	6–8	1–5	26–36
Malaysia	*IMI 326603*	submerged wood	32–47	27–35	10–13	4–5	5–7	1–5	26–35

*Includes basal cell.

darker than the basal rows. These differences have also been commented on by Rao and de Hoog (1986) and Nawawi and Kuthubutheen (1989). It is obvious that this species differs from *B. pulchrum* (sensu Nawawi and Kuthubutheen 1989) and it is therefore described here as *Canalisporium kenyense* sp.nov.

We have collected a further species from Hong Kong that superficially resembles *C. caribense*, but produces very pale conidia. Basically, these conidia possess a single column of vertical septa and 4–5 rows of transverse septa. In some of these conidia, one or two central rows of cells may possess 1–2 additional vertical septa. Each of these additional septa is provided with a septal canal. All the septa in the conidium are thin and unpigmented and the canals are clearly visible. These features separate this fungus from any of the described species of *Canalisporium* and it is therefore described here as *Canalisporium pallidum* sp.nov. With the addition of three species, the genus *Canalisporium* now consists of six taxa. Illustrations of conidia from various collections, drawn to the same scale for comparison, are provided (Figs. 49–63), as well as a key to the species of the genus.

Taxonomy

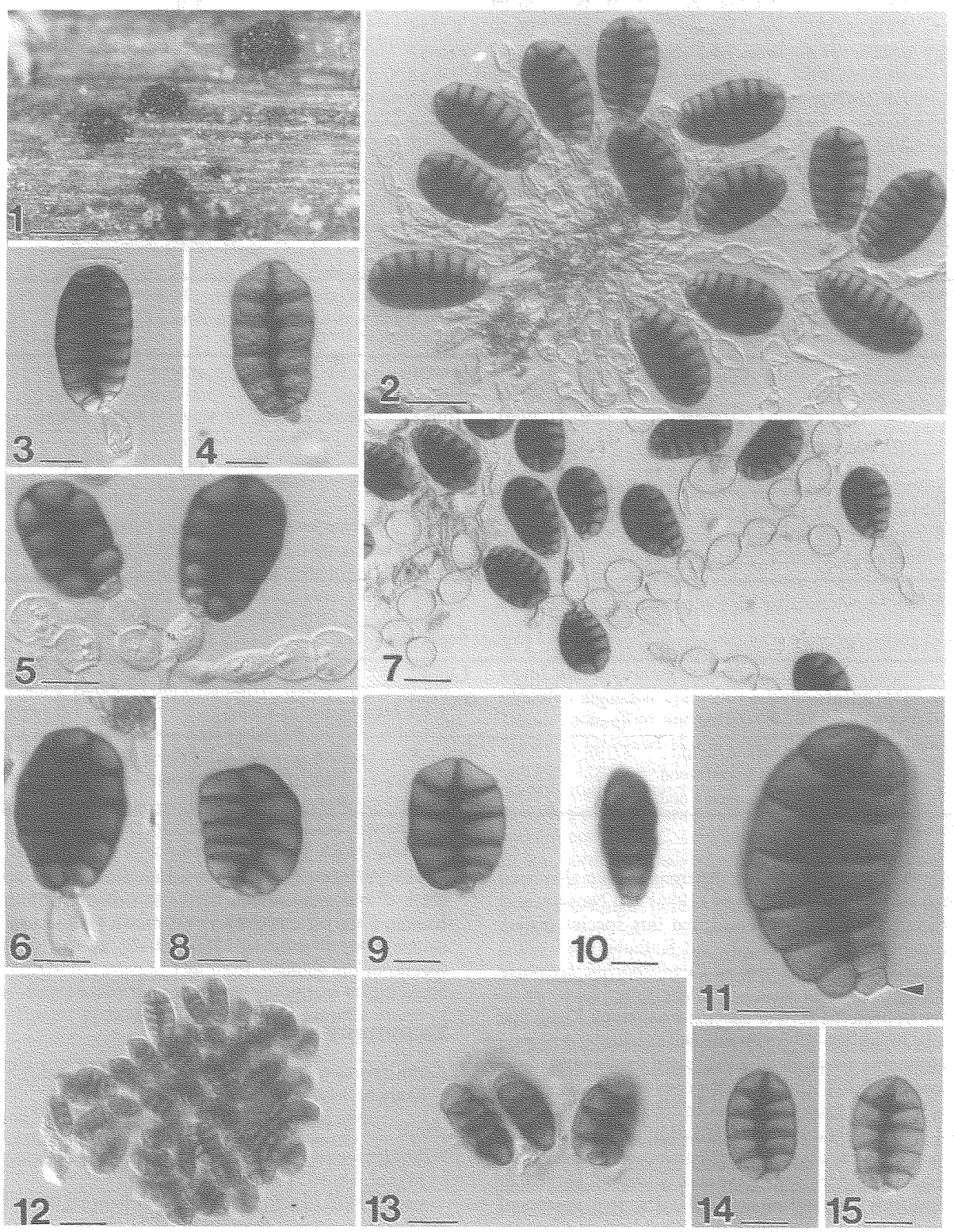
Canalisporium caribense (Hol.-Jech. & Mercado) Nawawi & Kuthub., Mycotaxon, 34: 479. 1989

Figs. 1–11, 49–56

≡*Berkleasmium caribense* Hol.-Jech. & Mercado, eská Mykol. 38: 99. 1984

SPECIMENS EXAMINED: BRUNEI, Temburong, Batu Apoi Forest Reserve, Sungai Belalong, Kuala Belalong Field Studies

Figs. 1–11. *Canalisporium caribense* from various localities. Figs. 1–4. Collection from Malaysia (*HKU(M) 2883*). Fig. 1. Sporodochia on submerged wood. Fig. 2. Squash mount of a portion of a sporodochium showing vesiculate conidiogenous hyphae and conidia. Figs. 3, 4. Conidia. Figs. 5, 6. Collection from Hong Kong (*HKU(M) 3401*) showing conidia with vesiculate cells. Note that the banding at the septa is very broad in this collection. Fig. 7. Squash mount in sterile water showing conidia and chains of vesiculate cells (*HKU(M) 2910*, Brunei). Figs. 8–10. Conidia (*HKU(M) 2883*, Malaysia), two in surface view and one in lateral view showing canals. Fig. 11. High magnification of a conidium (*HKU(M) 2910*, Brunei) showing minute frill (arrowed) at the basal cell resulting from rhexolytic conidial secession. **Figs. 12–15.** Conidia of *Canalisporium exiguum* (*HKU(M) 3349*, holotype, Australia). Note canals in conidia (Fig. 13). Scale bars for Fig. 1 = 200 μm; Figs. 2, 7, 12 = 20 μm; Figs. 3–6, 8–11, 13–15 = 10 μm.



Centre, Sungai Sitam, on submerged wood, 24 Oct. 1995, W.H. Ho and K.D. Hyde, *HKU(M) 2910*; ibid., Ashton's trail, on a decaying leaf of *Freycinetia* sp., 24 Oct. 1995, S.R. Whitton, *HKU(M) 4902*; ibid., *HKU(M) 4903*; ibid., on a decaying leaf of *Pandanus* sp., 25 Oct. 1995, S.R. Whitton, *HKU(M) 4904*; HONG KONG, New Territories, Tai Po, Tai Po Kau Country Park, on a senescent culm of *Bambusa* sp., June 1995, T.E. Umali and F. Layug, *HKU(M) 3401*; ibid., on submerged wood, 21 Sep. 1996, W.H. Ho, *HKU(M) 4838*; MALAYSIA, Kuala Lumpur, State Negara, Lipur Lentang Nature Reserve, on submerged wood, 7 Sept. 1995, K.D. Hyde, *HKU(M) 2883*; PHILIPPINES, Laguna, Los Baños, Mt. Makiling, Barangay Bagong Silang, on a decaying leaf of *Freycinetia multiploa*, 22 Oct. 1996, S.R. Whitton, *HKU(M) 4906*; PHILIPPINES, Quezon, Sinoloan, U.P. Site, Baranggay Magsaysay, on a decaying leaf of *Pandanus simplex*, S.R. Whitton, *HKU(M) 4905*; VANUATU, Efate, near Eton, on a decaying leaf of *Pandanus tectorius*, 27 Oct. 1996, E.H.C. McKenzie, *HKU(M) 4901*.

KNOWN DISTRIBUTION: Brunei, Cuba, Hong Kong, Kenya, Malaysia, Philippines, Taiwan, Uganda, Vanuatu.

NOTES: The characteristic darkened pigmentation around the septa of the conidia tends to be rather variable. For example, the variation is shown in two of our collections: the conidia of *HKU(M) 3401* (Hong Kong) have thick dark banding at septa (Figs. 5, 6, 51), whereas those of *HKU(M) 2883* (Malaysia) have comparatively less pigmentation around the septa (Figs. 2–4, 54). The canals are often difficult to see in surface view because of the darkened pigmentation; however, they are normally visible in lateral view (Figs. 10, 53, 55). Most of the conidia from various localities have three rows of transverse septa, although some may have up to six rows. Because of the variation in the number of rows of transverse septa, there is also a corresponding variation in cell number and size (Table 1).

Canalisporium exiguum Goh & K.D. Hyde, sp.nov.

Figs. 12–15, 57

ETYMOLOGY: *exiguum*: Latin: small, in reference to the size of the conidia.

Sporodochia minuta, usque 135 µm lata, ex conidiophoris et usque 60 conidiis composita. Mycelium ex hyphis laevibus, 1.5–2.5 µm latis, compositum. Conidiophora usque 25 µm longa et 2–3.5 µm lata. Conidiorum secessio rhexolytica. Conidia in conspectis superficialibus late ellipsoidea vel obovoidea, in conspectis lateralibus cylindrica vel clavata, pallide olivaceobrunnea vel pallide puniceobrunnea, muriformia, 18–25 × 13–15 × 5–8 µm, cum *Canalisporium caribense* similis sed parviora.

HOLOTYPUS: AUSTRALIA, north Queensland, Atherton Tablelands, Lake Barrine, on submerged wood, 24 Apr. 1996, K.D. Hyde and C.A. Pearce, *HKU(M) 3349*.

Sporodochia on natural substratum punctiform, minute, scattered, granular, black, glistening, up to 135 µm in diameter, consisting of conidiophores and up to 60 conidia. Mycelium mostly immersed in the substratum, composed of branched, septate, subhyaline to pale brown, 1.5–2.5 µm wide, smooth hyphae. Conidiophores micronematous or semi-macronematous, fasciculate, simple or sparsely branched, smooth, hyaline to subhyaline, up to 25 µm long, 2–3.5 µm wide. Conidiogenous cells integrated, terminal, determinate, cylindrical or often becoming swollen. Conidial secession rhexolytic. Conidia 18–25 × 13–15 × 5–8 µm, acrogenous, solitary, flattened, one cell thick, smooth, thick-walled, broadly ellipsoidal to obovoid in surface view, cylindrical to clavate in lateral view, pale olivaceous brown to pale pinkish brown, muriform, comprising of a single, straight to slightly curved column of vertical septa and 2–3(–4) rows of transverse septa, slightly constricted at the septa; septa becoming progressively darker with conidial maturity; cell lumen connected by narrow canals; basal cell subhyaline to very pale brown, cuneiform, 2.5–3.5 µm wide, with thinner wall.

KNOWN DISTRIBUTION: Australia.

NOTES: Conidia of C. *exiguum* are similar to those of C. *caribense* in having a single column of vertical septa, although they have fewer rows of transverse septa (i.e., 2–3(–4) in the former versus 3–6(–7) in the latter). The range of conidial sizes of *C. caribense* from various localities (Table 1; Figs. 49–56) are larger than the conidia of *C. exiguum* (Fig. 57) from Lake Barrine, Australia. In *C. exiguum*, the maximum length, width, and lateral thickness of its conidia are equal to the minimum of each respective dimension of those *C. caribense* collections.

Canalisporium pulchrum (Hol.-Jech. & Mercado) Nawawi & Kuthub., Mycotaxon, 34: 481. 1989

Figs. 16–22, 61–63

≡*Berkleasmium pulchrum* Hol.-Jech. & Mercado, eská Mykol. 38: 101. 1984

SPECIMENS EXAMINED: AUSTRALIA, north Queensland, Atherton Tablelands, Lake Barrine, on submerged wood, 24 Apr. 1996, K.D. Hyde and C.A. Pearce, *HKU(M) 3192*. BRUNEI, Temburong, Batu Apoi Forest Reserve, Sungai Belalong, Kuala Belalong Field Studies Centre, Sungai Sitam, on submerged wood, 24 Oct. 1995, W.H. Ho and K.D. Hyde, *HKU(M) 2911*; ibid., *HKU(M) 2915*; ibid., *HKU(M) 4507*; HONG KONG, New Territories, Plover Cove Reservoir, on submerged wood, 15 Nov. 1996, M. Wong and K.D. Hyde, *HKU(M) 4741*.

KNOWN DISTRIBUTION: Australia, Brunei, Cuba, Hong Kong, India, Malaysia.

NOTES: In comparing the five collections of *C. pulchrum* from different localities (Table 2), the conidia of the Brunei collection (*HKU(M) 2911*) are relatively larger and the species has the widest range in conidial dimensions, including number of cells per conidium (Figs. 16–18, 21, 62).

Canalisporium elegans Nawawi & Kuthub., Mycotaxon, 34: 484. 1989

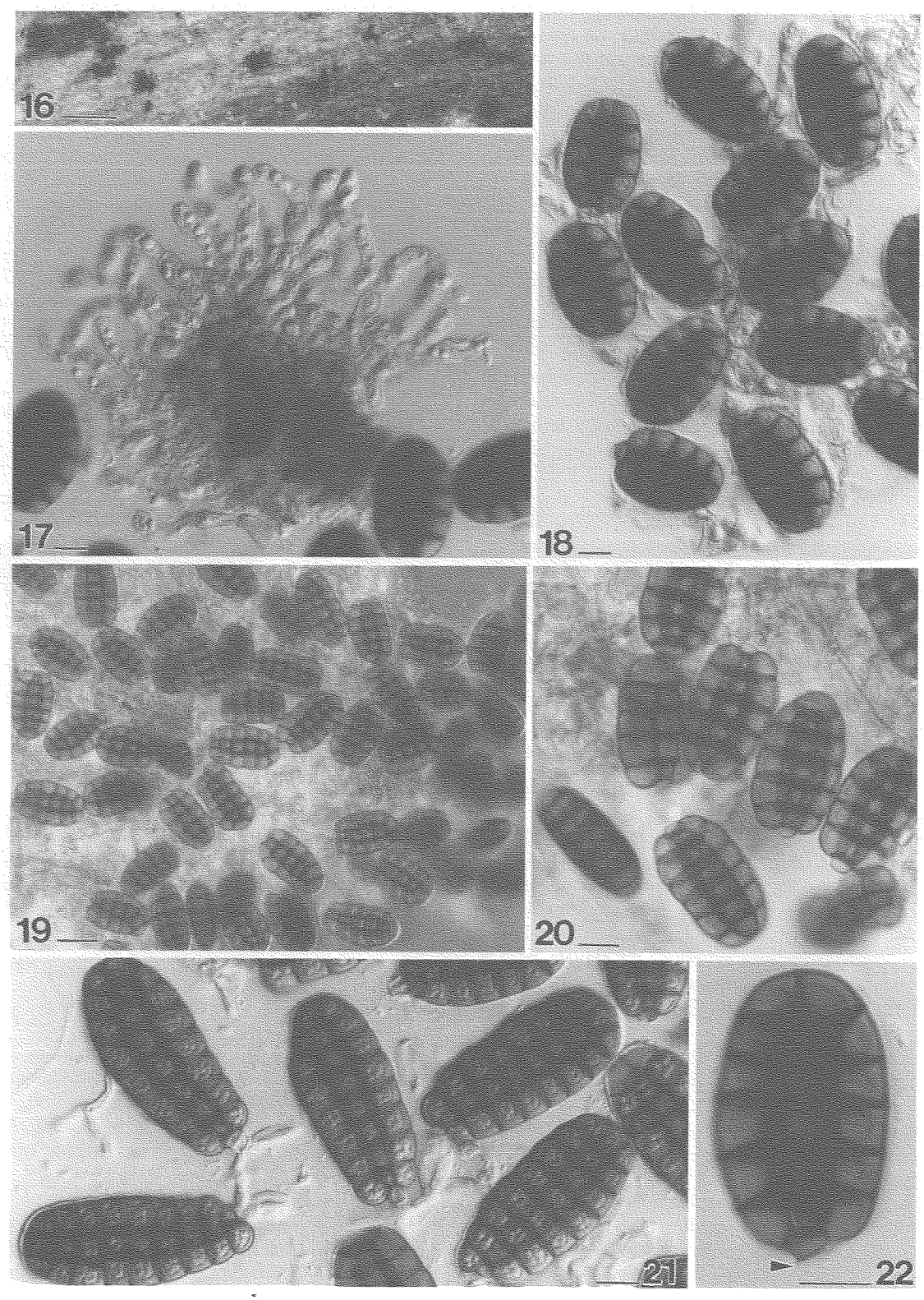
Figs. 23–31, 60

SPECIMENS EXAMINED: BRUNEI, Temburong, Batu Apoi Forest Reserve, Sungai Belalong, Kuala Belalong Field Studies Centre, Sungai Sitam, on submerged wood, 24 Oct. 1995, W.H. Ho & K.D. Hyde, *HKU(M) 2922*; ibid., *HKU(M) 2926*; ibid., Ashton's trail, on a decaying leaf of *Freycinetia* sp., 24 Oct. 1995, S.R. Whitton, *HKU(M) 4907*.

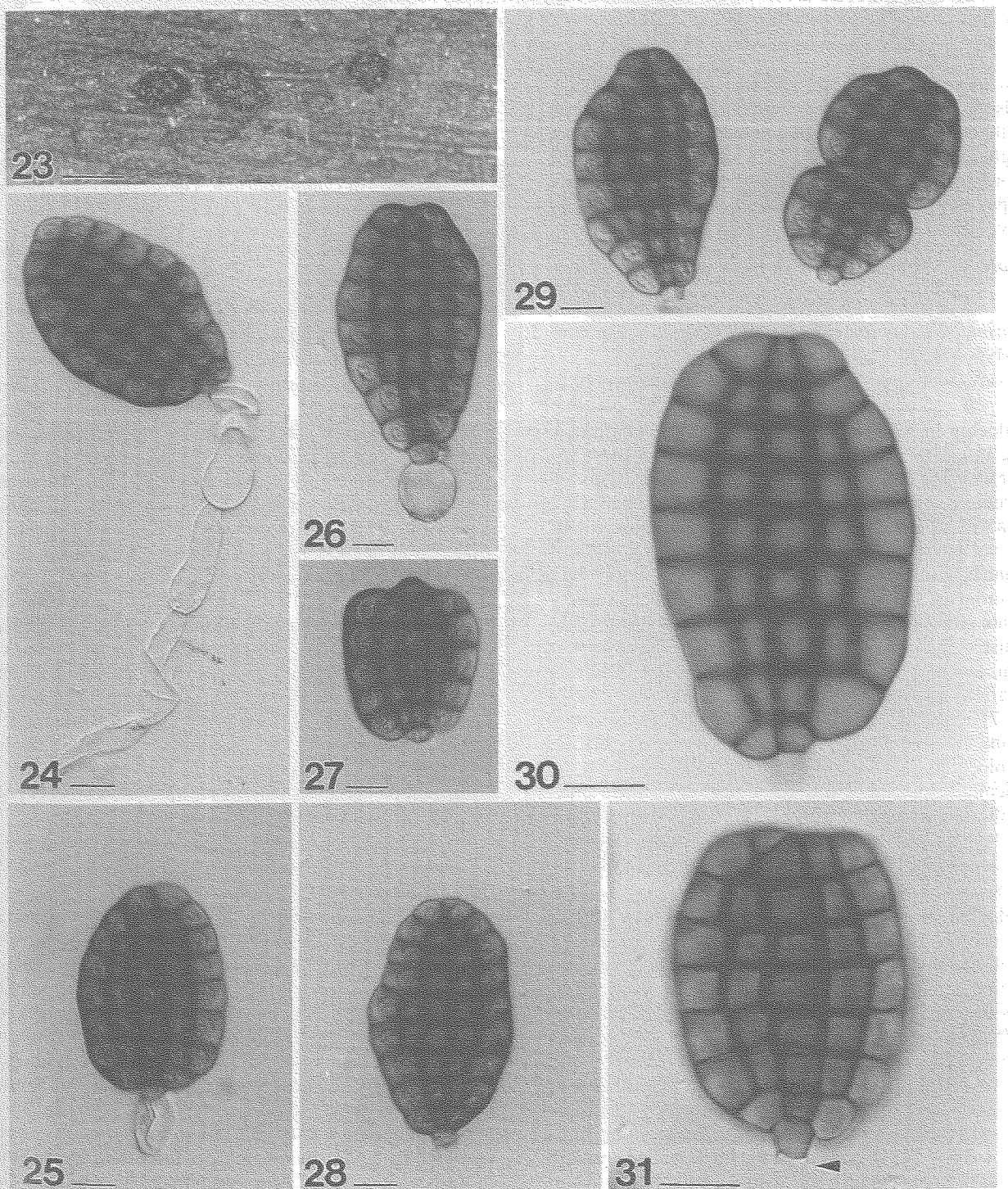
KNOWN DISTRIBUTION: Brunei, Malaysia.

NOTES: This species is relatively rare and it probably has a restricted distribution. In addition to the Malaysian specimen (*IMI 326603*, Nawawi & Kuthubuthen 1989), three collections were obtained from Brunei, two on submerged wood and the other from a decaying leaf of *Freycinetia* sp. (Table 3). The

Figs. 16-22. *Canalisporium pulchrum*. Figs. 16–18. Collection from Brunei (*HKU(M) 2911*): Fig. 16. Sporodochia on submerged wood. Fig. 17. Squash mount of a young sporochium showing fascicle of conidiogenous hyphae with swollen cells. Fig. 18. Conidia. Figs. 19, 20. Collection from Australia (*HKU(M) 3192*). Conidia. Note that banding in the septa is thinner in this collection and canals are visible in Fig. 20. Fig. 21. Collection from Brunei (*HKU(M) 2911*). Conidia. Note that the conidia have 8 rows of cells from this collection. Fig. 22. High magnification of a conidium (*HKU(M) 2911*) showing minute frill (arrowed) at the basal cell resulting from rhexolytic conidial secession. Scale bars for Fig. 16 = 200 μm; Fig. 19 = 20 μm; Figs. 17, 18, 20–22 = 10 μm.



Figs. 23–31. *Canalisporium elegans*. Collection from Brunei (*HKU(M) 2922*). Fig. 23. Sporodochia on submerged wood. Fig. 24. A conidium with a degenerated, vesiculate conidiogenous hypha attached to the base. Figs. 25, 26. Two conidia with vesiculate cells attached at the base. Figs. 27–29. Conidia. Fig. 30. Higher magnification of a conidium showing canals in the septa. Note that the majority of the canals are in the vertical septa. Fig. 31. High magnification of a conidium showing minute frill (arrowed) at the basal cell resulting from rhexolytic conidial secession. Scale bars for Fig. 23 = 200 µm; Figs. 24–31 = 10 µm.



Figs. 32–41. *Canalisporium kenyense* (*IMI 285428a*, holotype, Kenya). Figs. 32, 33. Sporodochia on rotten wood. Fig. 34. Squash mount of two sporodochia with mature conidia. Figs. 35–40. Conidia. Note that each conidium has three small cells in a row at the base and a single cell at the apex. Fig. 41. A conidium in lateral view. Scale bars for Figs. 32, 33 = 200 μm; Fig. 34 = 50 μm; Figs. 35, 36 = 20 μm; Figs. 37–41 = 10 μm.
Figs. 42–48. *Canalisporium pallidum* (*HKU(M) 5903*, holotype, Hong Kong). Fig. 42. Sporodochia on submerged wood. Fig. 43. Squash mount of a portion of a sporodochium showing conidia. Note that some of the conidia have an additional septa. Fig. 44. A mass of conidia with septa in focus. Fig. 45. The same mass of conidia with canals in focus. Note that each vertical septum is perforated by a canal, whereas only the transverse septa at the concave side of the conidia possess canals. Fig. 46. Three conidia, one in lateral view showing distinct canals. Note that the conidia in this species are pale and the septa are not banded. Figs. 47, 48. Conidiogenous hyphae bearing mature conidia and a young developing conidium (arrowed). Scale bars for Fig. 42 = 200 μm; Fig. 43 = 20 μm; Figs. 44–48 = 10 μm.

conidia of these collections are all identical in morphology. The canals that link the cell lumens are fairly distinct (Fig. 30), although the septa are darkly pigmented. Each vertical septum has a single canal, whereas along the transverse septa, canals are only present in the middle column of cells. Under the light microscope, these canals resemble the dolipore septa of many basidiomycetes.

Canalisporium kenyense Goh, W.H. Ho & K.D. Hyde, sp.nov. Figs. 32–41, 59

≡ *Berkleasmium pulchrum* Hol.-Jech & Mercado sensu P.M. Kirk, Mycotaxon, 23: 313. 1985

ETYMOLOGY: *kenyense*: in reference to the type locality in Kenya.

Sporodochia in substrato naturali dispersa, punctiformia, pulvinata, atra, 100–140 μm diam. Mycelium in substrato immersum, ex hyphis ramosis, septatis, laevibus, subhyalinis vel pallide brunneis, 2–3 μm latis compositum. Conidiophora micronemata vel semi-macronemata, mononemata, fasciculata, simplicia vel interdum ramosa, septata, hyalina vel pallidissime brunnea, laevia, usque 25 μm longa, 2–4 μm lata. Conidia acrogena, solitaria, complanata, in conspectis superficialibus late ellipsoidea vel pyriformia, in conspectis lateralibus anguste ellipsoidea vel clavata, 34–56 × 24–34 × 14–18 μm, laevia, crassitunicata, rubrobrunnea vel atrobrunnea, muriformia, cum septis longitudinalibus biserialis et (3–)4–5(–7) septis transversis in ordinem, atris, crassis praedita, lumina cellularum canaliculis connexa sed obscura, ad apicem unicellula (9–15 × 5–7 μm) terminaliter praedita, ad basem tricellulae parvae (2–3 × 1.5–2 μm) in ordinem praedita, conidiorum secessio rhexolytica.

HOLOTYPUS: KENYA, Mt. Kenya, Castle Forest, on rotten wood, 25 Jan. 1984, P.M. Kirk, *1593a*, *IMI 285428a*.

ISOTYPUS: *HKU(M) 3350*, slides.

Sporodochia on natural substrate scattered, punctiform, pulvinate, black, 100–140 μm in diameter. Mycelium immersed in the substrate, composed of branched, septate, smooth, subhyaline to pale brown, 2–3 μm wide hyphae. Conidiophores micronematous or semi-macronematous, mononematous, fasciculate, simple or sometimes branched, septate, hyaline to very pale brown, smooth, up to 25 μm long, 2–4 μm wide. Conidial secession rhexolytic. Conidia acrogenous, solitary, flattened, one cell thick, broadly ellipsoidal or pyriform in surface view, narrowly ellipsoidal to clavate in lateral view, 34–56 × 24–34 × 14–18 μm, smooth, thick-walled, reddish brown to dark brown, muriform, with 2 straight columns of vertical septa and (3–)4–5(–7) rows of transverse septa, slightly constricted at the septa, apical rows of cells darker than the basal rows, dark and thickly banded at the septa, canals in the septa obscured by dark pigmentation, apex comprising a single cell (9–15 × 5–7 μm), base comprising three thin-walled, pale small cells (2–3 × 1.5–2 μm) in a row.

KNOWN DISTRIBUTION: Kenya.

NOTE: The conidia of this species are the darkest amongst all known species of *Canalisporium*. The species is unique in having conidia with three small cells in a row at the base.

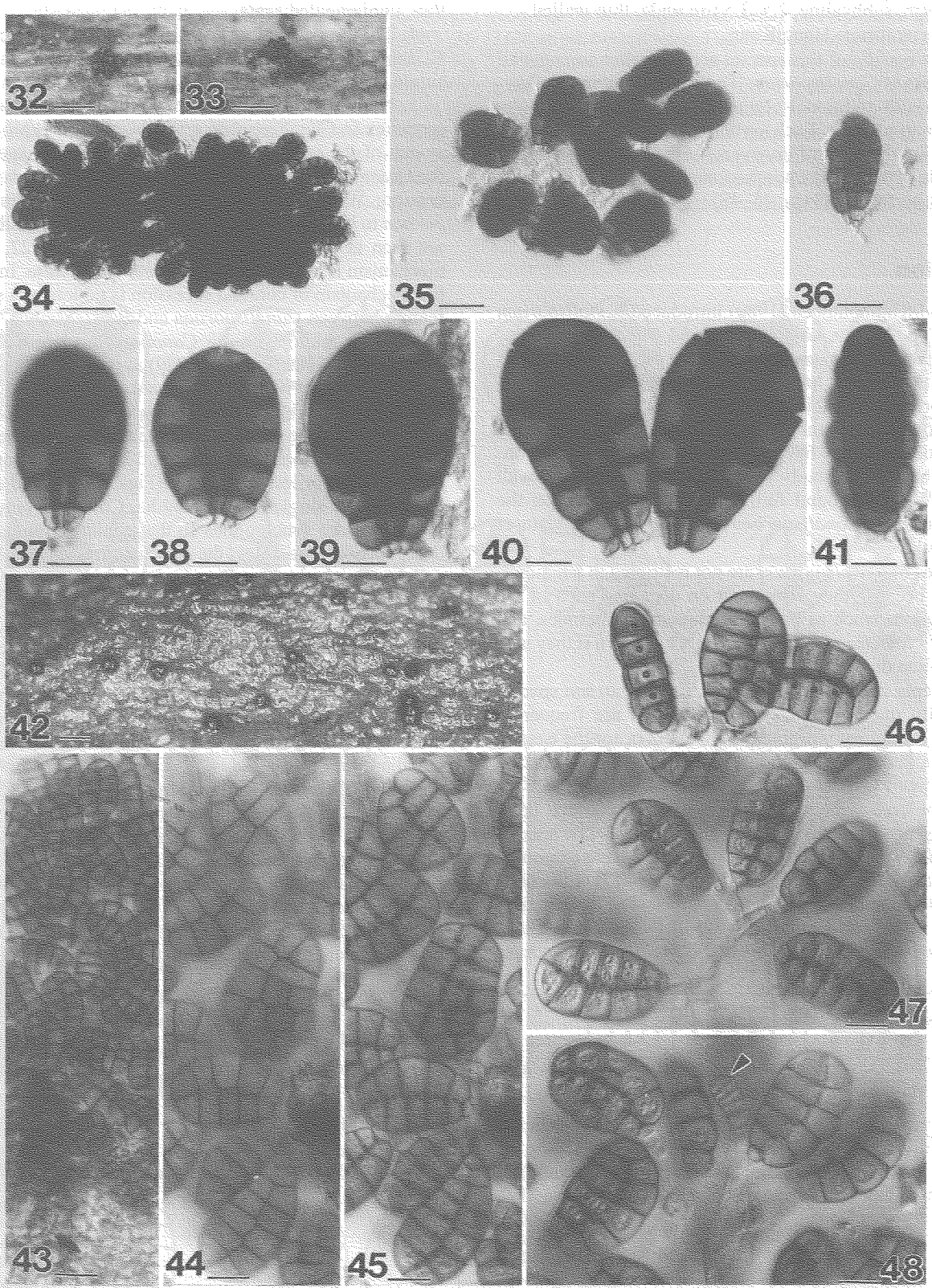
Canalisporium pallidum Goh, W.H. Ho & K.D. Hyde, sp.nov. Figs. 42–48, 58

ETYMOLOGY: *pallidum*: in reference to the pale color of the conidia, compared with other known species, which normally have darkly pigmented conidia.

Sporodochia in substrato naturali punctiformia, dispersa, granulata, atrogrisea, usque 200 μm lata. Mycelium plerumque in substrato immersum, ex hyphis ramosis, septatis, subhyalinis, 1.5–2.5 μm latis, laevibus, compositum. Conidiophora micronemata vel semi-macronemata, mononemata, fasciculata, simplicia vel sparse ramosa, laevia, hyalina vel subhyalina, usque 25 μm longa, 2–3 μm lata. Cellulae conidiogenae in conidiophoris incorporatae, terminales, determinatae, cylindricae vel leniter vesiculosae. Conidia 25–39 × (15–)16–20(–22) × 8–10 μm, acrogena, solitaria, complanata, laevia, in conspectis superficialibus plus minusve ellipsoidea vel obovoidea, leniter curvata, in conspectis lateralibus cylindrica vel late clavata, pallide olivacea vel pallidissime olivaceobrunnea, muriformia, plerumque cum septis longitudinalibus uniserialis et 4–5 septis transversis in ordinem, non vittatis, tenuis praedita, interdum cum 1–2 septis verticalis additis praedita, lumina cellularum canaliculis conspicue connexa, cellula basali cuneiformia, subhyalina, tenuitunicata, 2.5–3.5 μm lata, conidiorum secessio rhexolytica.

HOLOTYPUS: HONG KONG, New Territories, Tai Po, Tai Po Kau Country Park, on submerged wood, 29 Dec. 1996, W.H. Ho, *HKU(M) 5903*.

Sporodochia on natural substrate punctiform, scattered, granular, dark grey, up to 200 μm wide. Mycelium mostly immersed in the substrate, composed of branched, septate, subhyaline, 1.5–2.5 μm wide, smooth hyphae. Conidiophores micronematous or semi-macronematous, mononematous, fasciculate, simple or sparsely branched, smooth, hyaline or subhyaline, up to 25 μm long and 2–3 μm wide. Conidiogenous cells integrated, terminal, determinate, cylindrical or slightly vesiculate. Conidial secession rhexolytic. Conidia 25–39 × (15–)16–20(–22) × 8–10 μm, acrogenous, solitary, one-cell thick and flattened, smooth, more or less ellipsoidal or obovoid in surface view, slightly curved, cylindrical or broadly clavate in lateral view, pale olivaceous or very pale olivaceous brown, muriform, mostly with a slightly curved column of vertical septa and 4–5 rows of transverse septa, occasionally one or two of the central rows of cells may have additional 1–2 vertical



septa, septa unpigmented, thin and canals clearly visible, basal cell cuneiform, subhyaline, 2.5–3.5 μm wide, thin-walled.

KNOWN DISTRIBUTION: Hong Kong.

NOTE: The conidia of this species are the palest amongst all known species of *Canalisporium*. The species is unique in having conidia with additional vertical septa besides the single, central column of septa. Each vertical septum is perforated by a canal. Along the rows of transverse septa, only those on the concave side of the conidia possess canals; those on the convex side are not perforated (Figs. 45–48).

Discussion

Nawawi and Kuthubutheen (1989) introduced *Canalisporium* based on *C. caribense*, *C. pulchrum*, and *C. elegans*, species that have several common characters. They are all lignicolous with black, punctiform, nonstromatic sporodochia, which contain muriform conidia that are complanate, generally brown, and have longitudinal and horizontal rows of septa that are darkly pigmented. They have a single basal cell that is delimited from the conidial body in pigmentation, size, and wall thickness. We have found further features that broaden the generic concept of *Canalisporium* and some of these features are noted below.

1. Species of *Canalisporium* are not restricted to a lignicolous habitat because they also occur on decaying parts of the monocotyledons, such as bamboo culms, palm rachides, and leaves of *Freycinetia* and *Pandanus*. It is unknown if they also occur on fallen dicotyledonous leaves.

2. The septa in the conidia of most *Canalisporium* species are generally thickly banded and the canals are frequently obscured by this heavy pigmentation. This is not the case in *C. pallidum*, because the conidia are pale with clear septation and conspicuous canals.

3. The ordered arrangement of septa in the conidial body and the presence of septal canals in all *Canalisporium* species is unique amongst taxa of Hyphomycetes. We have examined the type material of *Berkleasmium leonense* M.B. Ellis (*IMI 103399a*), the conidia of which are composed of three-seriate cells (Ellis 1976) and similar to those of *C. pulchrum*. *Berkleasmium leonense*, however, is not a *Canalisporium* because its conidia lack septal canals, although the conidia are pale with thin, unpigmented septa.

4. The three smaller cells at the base of the conidia in *C. kenyense* are extraordinary, because most species have a single basal cell.

5. Nawawi and Kuthubutheen (1989) noted that conidial secession in *Canalisporium* was schizolytic and proposed this as one of the criteria separating *Canalisporium* species from *Berkleasmium*, which apparently has rhexolytic conidial secession. We have observed conidial secession in *Canalisporium* to be rhexolytic because minute frills of wall remnants are seen at the base of the conidia (Figs. 11, 22, 31). This mechanism is also seen in *Berkleasmium leonese*. In this case, the mechanism of conidial secession is no longer a separating feature between *Canalisporium* and *Berkleasmium*.

6. The conidiophores in *Canalisporium* are described by Nawawi and Kuthubutheen (1989) as semi-macronematous to macronematous. We have observed the conidiophores to be hypha-like (micronematous) or barely distinguishable from vegetative hyphae (semi-macronematous). They are normally aggregated in a loose fascicle (Fig. 17). The conidiophores are initially more or less cylindrical (Figs. 47, 48) and eventually give rise to a single crop of conidia. Conidium ontogeny and maturation are synchronous so that conidia from each sporodochium are more or less the same in terms of size, number of cells, and pigmentation. Developing conidia are normally embedded in a hyaline gelatinous sheath that may persist when the conidia mature. No proliferation is seen in the conidiophores. When the conidia mature, the hypha-like conidiophores swell and the cells become vesiculate (Figs. 2, 5, 7, 24). These swollen cells eventually disintegrate and the crop of mature conidia are released. Occasionally, one or more of these vesiculate cells may still be attached to the base of the conidia after conidial secession (Figs. 3, 6, 25, 26). This phenomenon, however, is more frequently encountered in *C. caribense*. Detached conidia that occasionally or consistently bear one or more vesiculate cells at the base are also seen in other hyphomycetes, e.g., *Berkleasmium corticola* (Karst.) Moore (Sharma 1980), *Dictyosporium gauntii* Bhat and Sutton (1985), *Monodictys paradoxa* (Corda) S. Hughes (Hughes 1951), and *Oncopodium antoniae* Sacc. (Ellis 1971). Whether this character is the result of conidiogenesis and conidial se-

Key to species of *Canalisporium*

1*a*. Conidia with three distinct small cells in a row at the base and a single cell at the apex ..... *C. kenyense*
1*b*. Conidia with a single basal cell and one (rarely), two or more cells in a row at the apex 2

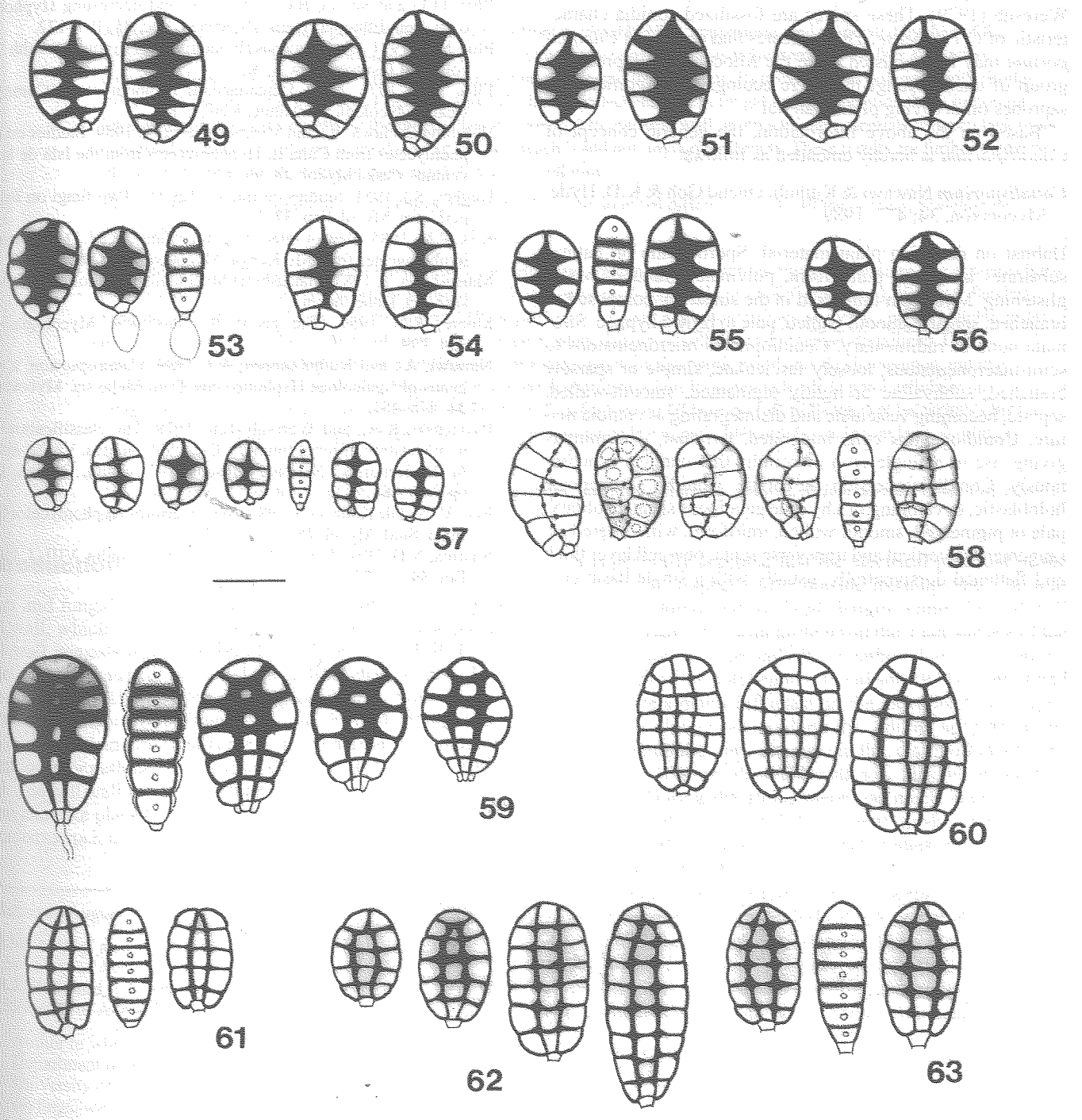
2*a*. Conidia with a single column of vertical septa but occasionally with a few additional, scattered, vertical septa, pale, olivaceous with clearly visible septa and canals, septa thin and not banded ..... *C. pallidum*
2*b*. Conidia with a single, double, or 4–5 column(s) of vertical septa, pale brown to dark brown, septa usually thick and darkly banded, canals obscured or not readily visible 3

3*a*. Conidia with a single column of vertical septa 4
3*b*. Conidia with two or more columns of vertical septa 5

4*a*. Conidia 24–51 × 15–29 × (8–)10–16 μm, with 3–6(–7) rows of transverse septa ..... *C. caribense*
4*b*. Conidia 18–25 × 13–15 × 5–8 μm, with 2–3(–4) rows of transverse septa ..... *C. exiguum*

5*a*. Conidia regularly with 2 columns of vertical septa, 25–63 × (16–)20–32 × 12–17 μm ..... *C. pulchrum*
5*b*. Conidia irregularly with 4–5 columns of vertical septa, 32–58 × 25–38 × 10–13 μm ..... *C. elegans*

Figs. 49–63. Conidia of *Canalisporium* spp. drawn at the same scale for comparison; scale bar = 20 μm. Figs. 49–56. *Canalisporium caribense* from various collections. Fig. 49. Brunei (*HKU(M) 2910*), on submerged wood. Fig. 50. Brunei (*HKU(M) 4902*), on *Freycinetia* sp. Fig. 51. Brunei (*HKU(M) 4904*), on *Pandanus* sp. Fig. 52. Hong Kong (*HKU(M) 3342*), on submerged wood. Fig. 53. Hong Kong (*HKU(M) 3401*), on bamboo culm. Fig. 54. Malaysia (*HKU(M) 2883*), on submerged wood. Fig. 55. Philippines (*HKU(M) 4906*), on *Freycinetia multiploa*. Fig. 56. Vanuatu (*HKU(M) 4901*), on *Pandanus tectorius*. Fig. 57. *Canalisporium exiguum* (*HKU(M) 3349*, holotype), on submerged wood from Australia. Note that the size of the conidia is distinctly smaller when compared with those of *C. caribense* and other *Canalisporium* species from various collections. Fig. 58. *Canalisporium pallidum* (*HKU(M) 5903*, holotype), on submerged wood from Hong Kong. Fig. 59. *Canalisporium kenyense* (*HKU(M) 3350*, isotype) on rotten wood from Kenya. Fig. 60. *Canalisporium elegans* (*HKU(M) 4907*) on *Freycinetia* sp. from Brunei. Figs. 61–63. *Canalisporium pulchrum* from various collections. Fig. 61. Australia (*HKU(M) 3192*), on submerged wood. Fig. 62. Brunei (*HKU(M) 2911*), on submerged wood. Note that this collection has a wide range of conidial size. Fig. 63. Hong Kong (*HKU(M) 4741*), on submerged wood.



cession similar to that found in *Canalisporium* species awaits further observations.

7. Species of *Canalisporium* have been successfully grown in pure culture (Matsushima 1987; Nawawi and Kuthubutheen 1989). We have also obtained several isolates of *C. caribense* from our collections. The colonies are slow-growing, dark brown, effuse, lacking aerial mycelium and comprise septate, straight, moderately branched, dark olivaceous, smooth hyphae. Chlamydospores in culture have been reported by Matsushima (1987). Neither clamp connections nor septal canals have been observed in the mycelium.

8. Fossilized spores of *Pleospora farlowiana* Rehm and an unnamed fossilized fungus are illustrated by Pirozynski and Weresub (1979). These spores are fossilized conidia characteristic of *C. caribense*. This indicates that species of *Canalisporium* may have existed since the Miocene and represent a group of ancient fungi that were ecologically significant as saprobes on decaying plant material.

Based on the above information, the generic concept of *Canalisporium* is hereby emended as follows:

Canalisporium Nawawi & Kuthub. emend Goh & K.D. Hyde. Mycotaxon, 34: 477. 1989

Habitat on decaying plant material. Sporodochia on natural substrates scattered, punctiform, pulvinate, granular, black, glistening. Mycelium immersed in the substrata, composed of branched, septate, smooth-walled, pale to brown hyphae. Stromata none or rudimentary. Conidiophores micronematous to semi-macronematous, loosely fasciculate, simple or sparsely branched, subhyaline or lightly pigmented, smooth-walled, septate, becoming vesiculate and disintegrating as conidia mature. Conidiogenous cells integrated, terminal, determinate, giving rise to a single crop of conidia that matures synchronously. Conidial secession rhexolytic. Conidia acrogenous, holoblastic, developing in a hyaline gelatinous sheath, solitary, pale or pigmented, smooth-walled, muriform, with ordered arrangement of vertical and transverse septa, one-cell layer thick and flattened dorsiventrally, usually with a single basal cell, but one with three small cells at the base. Cell lumen connected by septal canals that are normally barrel shaped and pigmented.

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